ECE 253a	Digital Image Processing	Handout #4	Pamela Cosman	10/12/08

HOMEWORK 2

Due Monday October 20 by start of class

1. **Contrast Enhancement**

   Use imread to read in the image named butterfly.tif. This shows a rather small butterfly on the background of lots of foliage. The foliage is unevenly illuminated. (Note that you will need to rescale the image amplitudes to run from 0 to 1 in order to use histeq or to try power law contrast enhancement. But you may perhaps need to return to the 0-255 range in order to look at the picture or to export it for printing in your homework.)

   (a) Try a couple of point processing transformations using power laws (with exponents both larger and smaller than 1). Describe the way your processed image looks in each case, and explain the reason why it looks that way.

   (b) The image processing toolbox has a built-in function named **histeq** which performs global histogram equalization. Type **help histeq** to find out about it. Run the histeq routine on the image. Describe the way the processed image looks. Is global histogram equalization a useful contrast enhancement method in this case? Why or why not?

   (c) Although Matlab does not include a routine that does adaptive histogram equalization, we can get a rough idea of what that might look like by using the command **blkproc** to perform histogram equalization on separate blocks. Type **help blkproc** to see how it works. Process the image using

   ```
   ahe = blkproc(im,[48,48],'histeq');
   ```

   The block boundaries are much more prominent in some parts of the image than in others. Where are the block boundaries most/least prominent in the image? Why? You should be able to identify at least two distinct image features which cause prominent block boundaries.

2. **Median Filtering**

(a) On the web site, you will find an original image named pep.tif and a noisy version of it called n2.tif. The noisy version was made from pep using the following commands:

```
noi = rand(256);
n2 = zeros(size(pep));
n2 = n2 + pep .* (noi >0.2) + 255 .* (noi<0.1);
```

What kind of noise is this?

(b) Write a routine that performs two-dimensional median filtering with the 5-point cross-shaped median filter. Use your median filter to clean it up.

Also you can use the command medfilt2 to do median filtering with different size filters. In addition to your cross-shape, try the following sizes: 1x2 1x3 2x2 3x3 3x4 4x4 4x5 5x5 7x7

If a median filter were able to perfectly clean up the noisy image, then the mean-squared error between the cleaned-up version and the original image would be zero. In practice, this doesn't happen. We can use the mean-squared error as a simple measure of how well a given median filter is doing. Plot the mean-squared error of the result versus the number of points in the filter for all the filters above, and for the cross-shaped filter. Include the mean-squared error between pep and n2 in your plot as well, as being unfiltered (a zero-point median filter).

Looking at this plot for the n2.tif image, explain what you see. That is, explain the ups and downs in the plot, and what is the best filter.

(c) Another noisy version of the image is n4.tif. Here the noise is twice as severe. Make the same kind of plot for this image. Compare the plots for n2 and n4: what can you say about them? In particular, explain the overall difference in MSE and the difference in the location of the minimum.

(d) A different original image is bab.tif. It's noisy version is bab2.tif, which has the same amount of noise as n2 does. Make the same kind of plot for this image. Compare the plots for n2 and bab2: what can you say about them?

3. **Unsharp masking**

(a) You are to spatially enhance an image using unsharp masking. Consider the following MATLAB function:

```
function im_out = unsharp( im_in, maskA, weight )

[a,b] = size( maskA );
maskB = zeros( size( maskA));
maskB(ceil(a/2),ceil(b/2)) = 1;
```

```
maskC = maskB - maskA;
maskD = maskB + weight * maskC;
im_out = conv2(im_in,maskD,'valid');
```

Here `im_in` is the input image and `im_out` is the output image. Suppose `maskA` is a small odd-sized lowpass filter mask, and `weight` is a positive number. What kind of masks are masks B, C and D? Using the discussion from class on separating an image into lowpass and highpass components, explain how this function performs edge sharpening.

(b) In unsharp masking there are basically two things you can choose: which lowpass filter to use and how much weight to give the highpass part. We will investigate the effect of each on the resulting image.

First, create a test image of size 128×128 that consists of a ramp and simple step function, as follows:

```
tst=ones(128,1)*[64*ones(1,32) (64:4:188) 192*ones(1,32) 64*ones(1,32)];
```

This has four equal sized areas (from left to right): first, 32 columns with value 64, then 32 columns of ramp going from 64 to 192, then 32 columns with value 192 and finally 32 columns with value 64.

Try a few combinations of low pass filters and weights. Vary the size of the mask (e.g., 3×3, 5×5, maybe even 7×7) and the entries in the mask (e.g., unweighted averaging vs. strongly center-weighted averaging) and vary the extra weight given to the highpass part. Discuss the results in each case, and note any trends you see that arise from varying the parameters. Also look at a slice of the filtered images:

```
plot(tst(64,:));
```

Include in your homework a few of the plots of horizontal slices through the filtered images, with discussions of the trends.

(c) Finally, let's look at a real-world example. Use the image `xray.tif` which is of size 384 by 384. Find a good combination of filter and weight so that the enhanced image "looks good". What has changed about the image? What can you say about the noise level? You may find that the values in the processed image exceed the range of $0 \rightarrow 255$, and so you may need to truncate or rescale the values. If you need to, does truncation or rescaling look better? With the right combination of masks and weights, can you discover what numbers are written on the vertebrae?